alkali-metal-ion conducting ceramic comprising alkali-metal-beta- or beta"-X_2O_3, where X comprises at least one of Al, or Ga.

2 ~~43~~. A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-ion conducting ceramic as in Claim 1 ~~42~~ wherein the precursor ceramic comprises Al_2O_3 and the precursor ceramic is converted into a continuous phase of alkali-metal-beta- or beta"-Al_2O_3.

3 ~~44~~. A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-ion conducting ceramic as in Claim 1 ~~42~~ wherein the precursor ceramic comprises Ga_2O_3 and the precursor ceramic is converted into a continuous phase alkali-metal-beta- or beta"-Ga_2O_3.

4 ~~45~~. A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-ion conducting ceramic as in Claim 1 ~~42~~ wherein the precursor ceramic comprises a mixture of alpha-Al_2O_3 and Ga_2O_3, and the precursor ceramic is converted into continuous matrix comprising a mixture alkali-metal-beta- or beta"-Al_2O_3 and alkali-metal-beta- or beta"-Ga_2O_3.

5 ~~46~~. A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-ion conducting ceramic as in Claim 4 ~~45~~ wherein the mixture of alkali-metal-beta- or beta"-Al_2O_3 and alkali-metal-beta- or beta"-Ga_2O_3 is a solution of alkali-metal-beta- or beta"-Al_2O_3 and alkali-metal-beta- or beta"-Ga_2O_3.

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67 ~~47.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-ion conducting ceramic as in Claim 62 ~~42~~ wherein the composite is subjected to a temperature of at least about 800°C.

68 ~~48.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-ion conducting ceramic as in Claim 62 ~~42~~ wherein the alkali metal comprises at least one of lithium, sodium, potassium, rubidium, or c~~a~~esium.

69 ~~49.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-ion conducting ceramic as in Claim 62 ~~42~~ wherein the alkali metal comprises at least one of sodium, or potassium.

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70 ~~50.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-ion conducting ceramic;

forming a shaped composite comprising a precursor ceramic of alpha-X_2O_3 and oxygen-ion conducting ceramic, such that a continuous matrix exists in the composite for both the precursor ceramic and the oxygen-ion conducting ceramic,

subjecting the composite in the presence of a stabilizer to a vapor containing metal oxide of an alkali metal at sufficient temperature and for sufficient time to convert precursor ceramic into a continuous phase of alkali-metal-ion conducting ceramic comprising beta"-X_2O_3, where X comprises at least one of Al, or Ga, the stabilizer inhibiting the transformation of the beta"-X_2O_3 to beta-X_2O_3.

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10 ~~51~~. A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-ion conducting ceramic as in Claim 9 ~~50~~ wherein the stabilizer comprises at lease one of MgO, Li_2O, or ZnO.

11 ~~52~~. A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina comprising;

forming a shaped composite comprising alpha-alumina and oxygen-ion conducting ceramic, such that a continuous matrix exists in the composite for both the alpha alumina, and the oxygen-ion conducting ceramic,

subjecting the composite to a vapor containing metal oxide of an alkali metal at sufficient temperature and for sufficient time to convert alpha-alumina into a continuous phase of alkali-metal-beta-alumina or alkali-metal-beta"-alumina.

12 ~~53~~. A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim 11 ~~52~~ wherein the composite is subjected to a temperature greater than about 800°C.

13 ~~54~~. A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim 11 ~~52~~ wherein the composite is subjected to a temperature between about 1200°C and 1500°C.

14 ~~55~~. A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim 11 ~~52~~ wherein the shaped composite of alpha-alumina and the oxygen-ion conductor is embedded in a powder that releases the vapor

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containing the alkali-metal oxide at the temperature to which the shaped composite of alpha-alumina and the oxygen-ion conductor is subjected.

15 ~~56.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim 14 ~~52~~ wherein the alkali metal comprises at least one of lithium, sodium, potassium, rubidium, or c~~a~~esium.

16 ~~57.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim 14 ~~52~~ wherein the alkali metal comprise at least one of sodium, and potassium.

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17 ~~58.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim 14 ~~52~~ wherein the alkali metal comprises sodium, the vapor comprises an oxide of sodium, and the alpha-alumina is converted to sodium beta- or beta"-alumina.

18 ~~59.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim 14 ~~52~~ wherein the alkali metal comprises potassium, the vapor comprises an oxide of potassium, and the beta-alumina is converted to potassium beta- or beta"-alumina.

19 ~~60.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim 14 ~~52~~ wherein the vapor also contains a

stabilizer to inhibit transformation of beta"-alumina to beta-alumina and the alpha-alumina is converted to alkali-metal-beta"-alumina.

20 ~~61.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim 19 ~~60~~ wherein the stabilizer comprises at least one of MgO, Li_2O, or ZnO.

21 ~~62.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim 19 ~~60~~ wherein the alkali metal comprises sodium, the alkali-metal oxide in the vapor comprises an oxide of sodium, and the alpha-alumina is converted to sodium beta"-alumina.

22 ~~63.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim 19 ~~60~~ wherein the shaped composite of alpha-alumina and the oxygen-ion conductor is embedded in a powder that releases the vapor containing the alkali-metal oxide and the stabilizer at the temperature to which the shaped composite of alpha-alumina and the oxygen-ion conductor is subjected.

23 ~~64.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina comprising;

forming a shaped composite comprising alpha-alumina and oxygen-ion conducting ceramic, such that a continuous matrix exists in the composite for both the alpha alumina, and the oxygen-ion conducting ceramic,

subjecting the composite in the presence of a stabilizer to a vapor containing metal oxide of an

alkali metal at sufficient temperature and for sufficient time to convert alpha-alumina into a continuous phase of alkali-metal-beta"-alumina, the stabilizer inhibiting the transformation of beta"-alumina to beta-alumina.

24 ~~65.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim ~~64~~ 23 wherein the stabilizer comprises at least one of MgO, Li_2O, or ZnO.

25 ~~66.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim ~~52~~ 12 wherein the oxygen-ion conductor comprises a ceramic comprising at least one of zirconia, ceria, hafnia, or thoria.

26 ~~67.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina as in Claim ~~52~~ 12 wherein the oxygen-ion conductor comprises a ceramic comprising at least one of yttria stabilized zirconia, rare-earth-oxide-doped zirconia, scandia-doped zirconia, rare-earth doped ceria, alkaline-earth doped ceria, stabilized hafnia, or thoria.

27 ~~68.~~ A process for forming ceramic composites of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-gallate comprising;

forming a shaped composite comprising alpha-gallate and oxygen-ion conducting ceramic, such that a continuous matrix exists in the composite for both the alpha gallate, and the oxygen-ion conducting ceramic,

subjecting the composite to a vapor containing metal oxide of an alkali metal at sufficient

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temperature and for sufficient time to convert alpha-gallate into a continuous phase of alkali-metal-beta- or beta"-gallate..

~~69.~~ A process for forming a ceramic composite of an oxygen-ion conducting ceramic and an alkali-metal-beta- or beta"-alumina or gallate comprising;

exposing to an alkali-metal oxide containing vapor a composite comprising a continuous phase of precursor ceramic of at least one of alpha-alumina, or alpha gallium oxide and a continuous phase of oxygen-ion conducting ceramic,

the exposing at a temperature sufficient to diffuse alkali metal ions through alkali-metal-beta- or beta"-phase converted from precursor ceramic and oxygen ions through the oxygen-ion conducting ceramic to a reaction front where precursor ceramic is converted from the alpha-phase to the alkali-metal-beta- or beta"-phase.

~~70.~~ A process for forming a ceramic composite comprising a continuous phase of oxygen-ion conducting ceramic and a continuous phase of at least one alkali-metal- beta"-alumina or alkali-metal- beta"-gallate, the process comprising;

exposing in the presence of a stabilizer a composite to an alkali-metal oxide containing vapor, the composite comprising a continuous phase of precursor ceramic comprising at least one of alpha-alumina, or alpha gallium oxide and a continuous phase of oxygen-ion conducting ceramic,

the exposing at a temperature sufficient to diffuse alkali metal ions through alkali-metal-beta- or beta"-phase converted from precursor ceramic and sufficient to diffuse oxygen ions through the oxygen-ion conducting ceramic to a reaction front where precursor ceramic is converted from the

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alpha-phase to the alkali-metal-beta"-phase, the stabilizer inhibiting transformation of the alkali-metal-beta"-phase to the alkali-metal-beta-phase.

31 ~~71~~. A ceramic composite comprising a continuous phase of an alkali-metal-ion conductor and a continuous phase of a ceramic oxygen-ion conductor, the alkali-metal-ion conductor comprising at least one of alkali-metal-beta-alumina, alkali-metal-beta"-alumina, alkali-metal-beta-gallate, or alkali-metal-beta"-gallate.

32 ~~72~~. A ceramic composite as in Claim 31 ~~71~~ wherein the alkali-metal of the alkali-metal-ion conductor comprises at least one of lithium-, sodium-, potassium-, rubidium- or caesium.

33 ~~73~~. A ceramic composite as in Claim 31 ~~71~~ wherein the alkali-metal-ion conductor comprises at least one of sodium-beta"-alumina or potassium-beta"-alumina.

34 ~~74~~. A ceramic composite as in Claim 31 ~~71~~ wherein the alkali-metal-ion conductor comprises sodium-beta"-alumina.

35 ~~75~~. A ceramic composite as in Claim 31 ~~71~~ wherein the ceramic oxygen-ion conductor comprises a ceramic comprising at least one of zirconia, ceria, hafnia, or thoria.

36 ~~76~~. A ceramic composite comprising a continuous phase of at least one of alkali-metal-beta-alumina or alkali-metal-beta"-alumina and a continuous phase of a ceramic oxygen-ion conductor.

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37 ~~77.~~ A ceramic composite as in Claim 36 ~~76~~ wherein the alkali-metal-of the alkali-metal-beta-alumina or alkali-metal-beta"-alumina comprises lithium-, sodium-, potassium-, rubidium- or caesium.

38 ~~78.~~ A ceramic composite as in Claim 36 ~~76~~ wherein the alkali metal of the alkali-metal-beta-alumina comprises at least one of sodium- or potassium.

39 ~~79.~~ A ceramic composite comprising a continuous phase of at least one of sodium-metal-beta-alumina or sodium-metal-beta"-alumina and a continuous phase of a ceramic oxygen-ion conductor.

40 ~~80.~~ A ceramic composite as in Claim 36 ~~76~~ wherein the ceramic oxygen-ion conductor comprises a ceramic comprising at least one of zirconia, ceria, hafnia, or thoria.

41 ~~81.~~ A ceramic composite as in Claim 36 ~~76~~ wherein the ceramic oxygen-ion conductor comprises a ceramic comprising at least one yttria stabilized zirconia, rare-earth-oxide-doped zirconia, and scandia-doped zirconia, rare-earth doped ceria and alkaline-earth doped ceria, stabilized hafnia, or thoria.

42 ~~82.~~ A ceramic composite comprising a continuous phase comprising alkali-metal-beta- or beta"-gallate and a continuous phase of a ceramic oxygen-ion conductor.

43 ~~83.~~ A ceramic composite comprising a continuous phase of a mixture of alkali-metal-beta- or beta"-alumina and of alkali-metal-beta- or beta"-gallate, and a continuous phase of a ceramic oxygen-ion conductor.

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